Effect of Added Sulfur Fertilizer on Recovery of Manure Nitrogen in a Sulfur Deficient Luvisol

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Abstract
Intensive hog operations generate large amounts of manure that must be dealt with in a manner that is both economically and environmentally sound. The objective of the research described is to evaluate the effect of supplemental sulfur (S) fertilizer as means of enhancing crop recovery of liquid swine manure (LSM) nitrogen (N). A long - term swine manure field trial located on a Gray-Black Chernozem with loam texture near Melfort, SK was used in the study. The application of 37,000 L ha^{-1} LSM supplied approximately 80-100 kg N ha^{-1}, and approximately 7-10 kg S ha^{-1} in the year of application. Supplemental S fertilizers in the form of elemental S and potassium sulfate were applied at one end of the treatments at a rate of 40 kg ha^{-1} every three years starting in 2002 and repeated in 2005. Supplemental S fertilizers were evaluated using measurements of seed yield and crop N recovery. Grain N concentration and fall soil N was also investigated. Data obtained in the 2005 and 2006 field season indicate that the low rate LSM of 37,000 L ha^{-1} supplied sufficient amounts of N and S to maximize seed yield and N recovery. The 80 kg N ha^{-1} urea treatment showed significant increases in seed yield and crop N recovery with supplemental S fertilizers.

Introduction

Intensive hog operations are capable of generating large amounts of manure. This manure must be dealt with in such a way that is economical and environmentally sound. Previous work has suggested that S could be a limitation in swine manured fields that are inherently low in available S. The focus of this experiment was to examine possible ways of increasing the plant uptake of manure nitrogen applied to the soil, with the goal of using the nitrogen supplied in the manure more efficiently.

Hypothesis and Objective

The hypothesis of the experiment is that addition of supplemental S fertilizer to swine manure treated soil will lead to an increased recovery of manure nitrogen. The objective is to evaluate the role of supplemental S fertilizer as a means of increasing the utilization of manure nitrogen by crops.

Material and Methods

The experimental site was located near Melfort, Saskatchewan. The soil at the Dixon site is a Gray-Black Chernozem, with a loam texture. Test plots were 30.5 meters long by 3.9 meters wide with sub-treatments of elemental S and potassium sulfate fertilizer 3.05 meters wide each applied to the east end of all treatments. The experiment was a randomized complete block design (RCBD) replicated 4 times. Treatments that were investigated were 0 L ha^{-1}, 37,000 L ha^{-1} (applied every year), 74,000 L ha^{-1} (applied every second year), 148,000 L ha^{-1} (applied every third year) and 80 kg N ha^{-1} Urea. Supplemental S fertilizers were applied at 40 kg ha^{-1} every three years starting in 2002 and reapplied in 2005. Canola was the crop grown in 2005 and barley in 2006. Plant samples were collected at harvest and threshed to determine seed yield. Grain N concentrations were determined on threshed samples. Fall soil samples were taken after each field season and analyzed for NH_4^+ and NO_3^-. All manure fertilizers were injected into the soil with Bourgault coulter openers.

Results and Discussion

2005

Supplemental elemental S and potassium sulfate fertilizer treatments were reapplied in the same strips as 2002 in the spring of 2005 at a rate of 40 kg S ha^{-1}. No significant differences in seed yield were observed in the LSM treatments of canola (Figure 1). A large significant difference in seed yield was observed in the 80 kg N ha^{-1} urea treatment. Both the elemental S and potassium sulfate fertilizers were significantly higher than the urea treatment alone, but were not significantly different from each other. The urea alone treatment, without S fertilizer, was not able to set any seed, as the seed yield was 1 kg ha^{-1}. The lack of seed yield was likely caused by the high S demand of the canola crop combined with the N supplied by the urea and little or no S supplied by soil or fertilizer, resulting in a nitrogen induced sulfur deficiency and toxicity (Malhi et al. 2005). No significant differences in seed yield measured in the year of application between LSM treatments that did and did not receive supplemental S fertilizer is in contrast to earlier work reported by Schoenau and Davis (2006). Schoenau and Davis (2006) found significant increases in oat yield in 2002 at the same experimental site when 40 kg ha^{-1} of supplemental S fertilizer was added to the 37,000 L ha^{-1} and the 80 kg N ha^{-1} urea treatments.

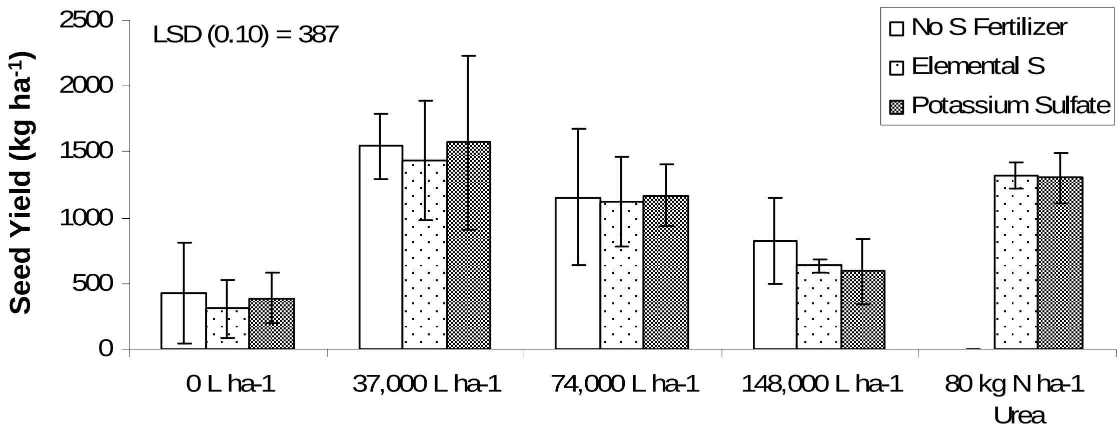

Figure 1. Canola seed yield at Melfort, SK. in 2005, without and with sub-treatments of sulfur fertilizer.

Crop nitrogen recovery was not significantly different in the LSM treatments without and with supplemental S fertilizer (Figure 2). The crop N recovery in the 80 kg N ha^{-1} urea treatment was significantly higher with both of the supplemental S fertilizers. Although not significant, it is interesting to note that the seed yield and % N recovery was similar and slightly higher in the elemental S fertilizer sub-treatments. Seed yield and % N recovery could be higher in the elemental S treatment due to higher S availability. Conditions of the 2005 field season may have been adequate to oxidize sufficient amounts of elemental S, from the 2005 and 2002 season application to maximize yield.

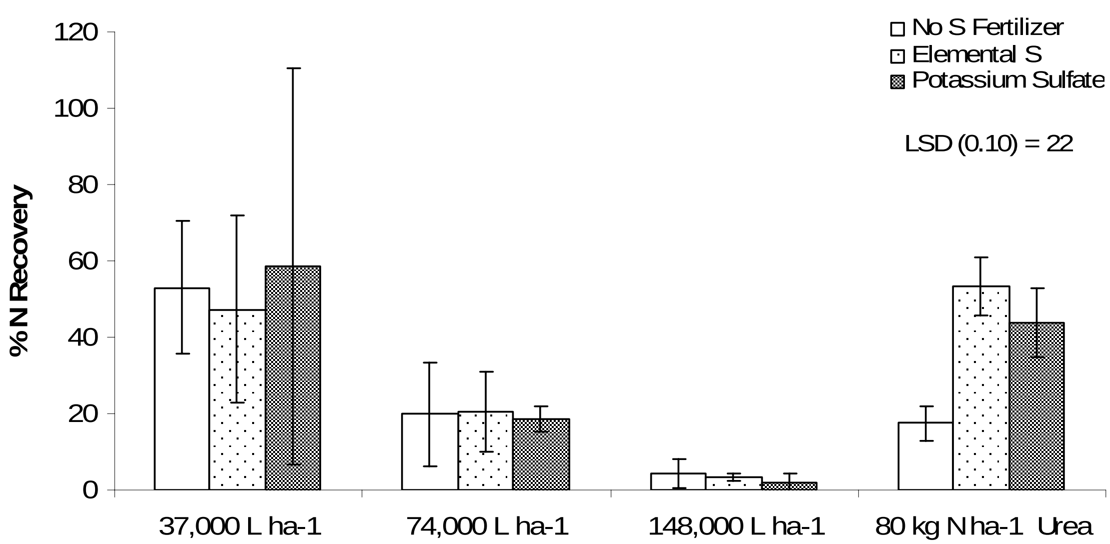

Figure 2. % N Recovery of Canola at Melfort, SK. in 2005, without and with sub-treatments of sulfur fertilizer.

Grain N concentration was not significantly different in the LSM treatments with or without S fertilizer added but was significantly increased by the addition of both S fertilizers in the urea fertilizer treatment.

Fall soil samples were taken at 0-30, and 30-60 cm depth increments. Significant differences in NH_4^+ were observed in all treatments at the 0-30 cm depth increment with the exception of the 0 L ha^{-1} treatment. In all treatments with significant differences, the sub-treatments of S fertilizers had lower NH_4^+ concentrations than without S fertilizer. This may reflect higher N removal by the crop in the S sub-treatments. No significant differences in NO_3^- were observed in any of the treatments without or with supplemental S fertilizer at the 0-30 cm depth. Concentrations of NH_4^+ and NO_3^- were not significantly different at the 30-60cm depth with the exception of NO_3^- in the 74,000 L ha^{-1} (applied every 2 years) treatment. In the 74,000 L ha^{-1} (applied every 2 years) treatment, the sub-treatment of potassium sulfate was significantly higher than the treatment without S fertilizer but not significantly different than the elemental S fertilizer sub-treatment, which was also not significantly different from the treatment without S fertilizer.

2006

In 2006, the second year following reapplication of the S fertilizer treatments, the seed yield of barley was significantly affected in the 37,000 L ha^{-1} LSM and 80 kg N ha^{-1} urea treatments (Figure 3). Seed yield was not significantly affected by S fertilizers in all other treatments. In the 37,000 L ha^{-1} LSM treatment without S fertilizer, seed yield was significantly higher than in the potassium sulfate, but was not significantly different from the elemental S sub-treatment. The two different S fertilizer forms were not significantly different from one another. Higher grain yield in the 37,000 L ha^{-1} with no S fertilizer could be a result of significantly higher amounts of NH_4^+-N observed in the 0-30 cm depth in the fall of 2005. Elemental S fertilizer in the 80 kg ha^{-1} urea treatment resulted in significantly higher seed yield than the treatment without any S fertilizer but not significantly different than potassium sulfate. Sulfur supplied through the LSM in the 37,000 L ha^{-1} treatment appears to have sufficient amounts of S to alleviate any S deficiency issues and maximized yield. Significant increases in seed yield with the addition of S fertilizers in the 80 kg N ha^{-1} urea treatment is similar to results reported by Schoenau and Davis (2006), where oat responded strongly to supplemental S fertilizer.

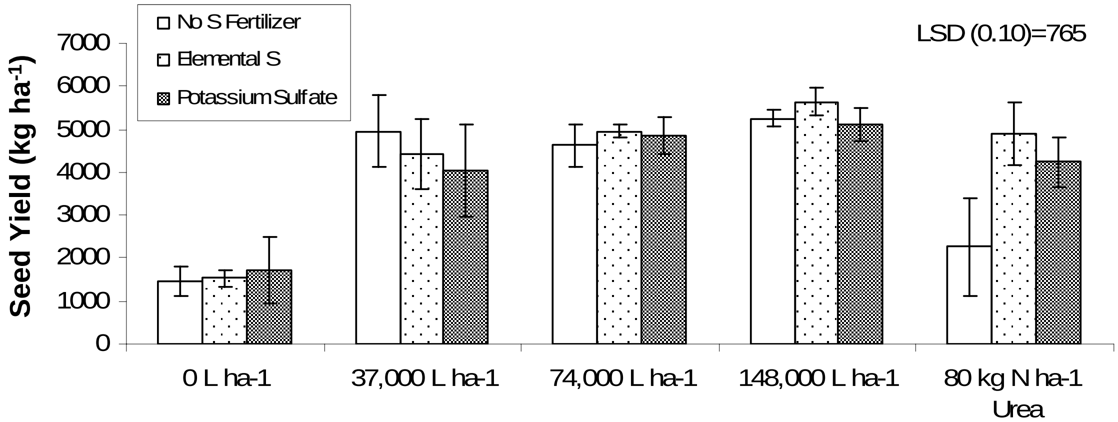

Figure 3. Barley seed yield at Melfort, SK. in 2006, without and with sub-treatments of sulfur fertilizer.

Crop N recovery was not significantly affected by S fertilizer treatment in the 74,000 L ha^{-1} and 148,000 L ha^{-1} LSM treatments, but was significantly different in the 37,000 L ha^{-1} LSM and 80 kg N ha^{-1} urea treatments (Figure 4). In the 37,000 L ha^{-1} LSM treatment, crop N recovery was significantly higher without any supplemental S fertilizer compared to the two sub-treatments of S fertilizer which were not significantly different from one another. In the 80 kg N ha^{-1} urea treatment, the sub-treatment of elemental S fertilizer had a significantly higher %N recovery than the sub-treatment of potassium sulfate, but not significantly different than the treatment without any supplemental S fertilizer.

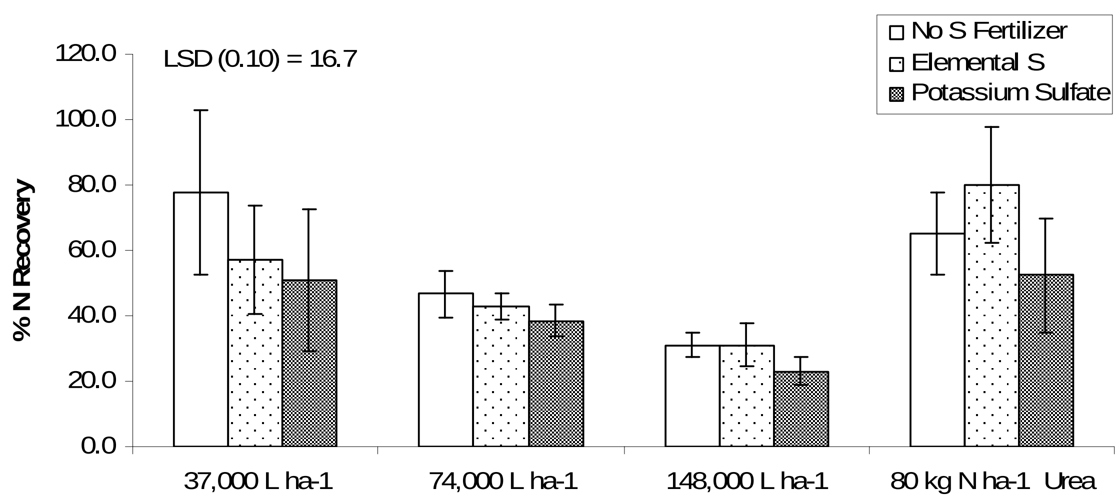

Figure 4. % N Recovery of Barley at Melfort, SK. in 2006, without and with sub-treatments of sulfur fertilizer.

Grain N concentrations were not affected by treatment in the 0 L ha^{-1} and 148,000 L ha^{-1} LSM treatments. Significant differences in grain N were observed in the 37,000 L ha^{-1} LSM, 74,000 L ha^{-1} LSM and 80 kg N ha^{-1} urea treatments. In the 37,000 L ha^{-1} LSM treatment grain N concentration was significantly higher in the potassium sulfate sub-treatment compared to the elemental S sub-treatment but not significantly different from the treatment without supplemental S fertilizer. In the 74,000 L ha^{-1} LSM treatment significantly higher grain yield was observed without any supplemental S fertilizer compared to the sub-treatment of elemental S fertilizer but was not significantly different from the sub-treatment of potassium sulfate. The two sub-treatments of S fertilizer were not significantly different from one another in the 74,000 L ha^{-1} LSM treatment.

No significant differences were observed in fall soil samples for NH_4^+ and NO_3^- content in the 0-30 and 30-60 cm.

Discussion

Overall, the supplemental S fertilizers did not have a large effect on seed yield or grain N in manured treatments in the 2005 and 2006 field season. It appears that the LSM was able to supply sufficient amounts of available S to maximize yield. These results are in contrast to work in previous years where significant responses to supplemental S fertilizer were observed. The effects of supplemental S fertilizers on manure N recovery were minimal. Variability in the results may be due to variation in manure nutrient composition, and environmental conditions over the seasons.

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References:

Malhi, S.S., E.D. Solberg, and M. Nyborg. 2005. Influence of formulation of elemental S fertilizer on yield, quality and S uptake of canola seed. Can. J. Soil Sci. **85**:793-802.

Schoenau, J.J., and J. G. Davis. 2006. Optimizing soil and plant responses to land-applied manure nutrients in the Great Plains of North America. Can. J. Soil Sci. **86**:587-595